DESCRIPTION OF PROPOSED EXPERIMENTATION

Pursuant to Sections 5.54, 5.61, and 5.64 of the rules of the Federal Communication Commission ("Commission")[1], Care Weather Technologies ("Care Weather") respectfully requests experimental special temporary authorization ("STA") for a period of six months in order to launch and operate its Veery-FS1 low-Earth orbit 1p pocketqube with a Care Weather Trill radio transmitting in the 137.935-137.995 MHz band and receiving in the 149.1-149.15 MHz band, as well as an Iridium 9603 modem transmitting and receiving in the 1618.725-1626.5 MHz band.

The experimental STA is necessary for on-orbit testing and validation of new Care Weather custom subsystems required to enable Care Weather to fill critical gaps in U.S. weather capabilities. To ensure successful demonstration, this experiment focuses on a limited set of newly-developed, custom satellite bus subsystems including VHF communications, high-speed computing, high-accuracy attitude determination, and high-authority attitude control subsystems. An experiment focused on the satellite bus is required to advance the readiness of Care Weather's satellite bus technologies for tight integration with its future satellite wind-sensing radar (a "scatterometer"). The resulting volume optimization will enable Care Weather to reduce instrument costs and map ocean surface vector winds 10X more frequently. With this capability, Care Weather will improve hurricane forecasting to combat the dramatically rising cost of hurricanes to American infrastructure. Timely grant of the requested experimental STA request would therefore strongly serve the public interest.

[1] *See* 47 C.F.R. §§ 5.54, 5.61, and 5.64.

I. Background

Of all the satellite datasets incorporated into global numerical weather forecasts, ocean surface vector winds measured by scatterometers improve forecast accuracy more than measurements from any other satellite sensor.[2] Unfortunately, these measurements are one of the least available by quantity of measurements.

In the 1980s and 1990s, the United States led the world in satellite scatterometer development and operation with the NSCAT and SeaWinds scatterometers. While recent dramatic growth in hurricane damages has underscored the need for improved weather forecasting, the U.S. has fallen behind in scatterometry, decommissioning its last scatterometer in 2016. The United States has become fully reliant on foreign governments for this critical dataset. The development and operation of new scatterometer systems is a priority for national security, weather and maritime safety, and for U.S. leadership in space and weather forecasting. Many follow-on missions have been proposed, but all have been too cost prohibitive for limited national Earth science budgets.

Care Weather's mission is to reinstate U.S. leadership in scatterometry by reducing the cost of scatterometers by multiple orders of magnitude. Such cost reduction requires significant volume optimization through tight integration of the satellite bus and sensor. This cannot be accomplished using off-the-shelf bus subsystems, because many individual components must integrate bus and sensor functionalities. Therefore, Care Weather must develop in-house bus

[2] See "Impact per observation" in Giovanna De Chiarra, et al. "On the impact of scatterometer winds in coupled and uncoupled DAS: preliminary results." International Ocean Vector Winds Science Team Meeting. 2017.

technologies and prove them on orbit to achieve its mission of providing domestic scatterometry.

To this end, Care Weather is building the Veery-FS1 ("Hatchling Veery") satellite to flight qualify a custom satellite bus subsystems including VHF communications, high-speed computing, high-accuracy attitude determination, and high-authority attitude control subsystems. In addition, Veery-FS1 provides an opportunity to further miniaturize the custom satellite computing, power, and avionics systems flight proven by Care Weather on the successful Veery-RL1 satellite.

Verification of these systems on-orbit will provide Care Weather with the technical assurance required to further integrate them with Care Weather's nanosatellite scatterometer, "Veery," on later missions. Such later experiments will advance development of Care Weather's integrated solar panel, antenna, and radiator ("SPAR") and software defined radar technologies to permit tight integration and miniaturization of satellite subsystems.[3] The Veery-FS1 mission is an important step toward Care Weather's goal of increasing the rate of ocean surface vector wind measurement ten-fold to provide earlier warnings for hurricanes and other forms of extreme weather.

Care Weather originally applied for the Veery-FS1 mission in June, 2020 under the "Canary Hatchling 1" mission name, but the launch was delayed to 2022. Care Weather

[3] Care Weather recently proposed a nanosatellite scatterometer using SPAR and software-defined radar to the NASA Earth Science Technology Office, in partnership with NASA Marshall Space Flight Center and Brigham Young University. Care Weather also recently proposed a nanosatellite scatterometer constellation to the Space Development Agency. However, before developing these integrated systems, Care Weather must develop and test individual component technologies such as those included in the Veery-FS1 mission.

withdrew the original application to simplify processing for the stopgap Veery-RL1 mission of March, 2021. Care Weather is now renewing its pursuit of the Veery-FS1 mission.

II. Discussion

A. Veery-FS1 Satellite

Veery-FS1 subsystems include power, command and computing, communications, drag panels, deployment mechanism, attitude determination, and attitude control. The power subsystem includes solar panels, lithium-polymer batteries, and power management circuit boards. The command and computing subsystem includes a watchdog, a thermal timeout system, microcontroller, and microprocessor. The communications subsystem includes an Iridium 9603 satellite modem with body-mounted patch antenna (not deployed) and Trill 1001, a custom VHF radio developed and manufactured by Care Weather, with deployed, tape-spring dipole antenna.

The drag panel subsystem includes four 5cm x 25cm accordion-folded drag panel arrays, each with five panels, deployed from four of the satellite faces. The deployment mechanism subsystem includes a servo-driven latch that closes to hold the drag panels in their stowed position and opens on orbit to release the drag panels into their deployed position. The attitude determination subsystem includes a star tracker, an inertial measurement unit, and six sun-sensing photodiodes. The attitude control subsystem includes three magnetorquers.

In conformance with the Process for Limiting Orbital Debris, NASA-STD-8719.14A, the Veery-FS1 satellite does not generate debris as part of normal operations, there is no material probability for on-orbit breakup, no debris will survive re-entry, and there is very low probability for an on-orbit conjunction and human casualty risk. The satellite will be launched

into a 500 - 550 km circular orbit with an inclination of 96.5°. In the most conservative case, where Veery-FS1 is launched into the highest altitude and its drag panels fail to deploy, the orbital lifetime of the spacecraft is estimated to be approximately 4 years until full demise (well within the current 25-year benchmark).

As described in more detail in the attached Orbital Debris Assessment Report[4] and for the avoidance of doubt, Care Weather has (i) assessed and limited the amount of debris released in a planned manner during normal operations, and has assessed and limited the probability of the space station becoming a source of debris by collisions with small debris or meteoroids that could cause loss of control and prevent post-mission disposal; (ii) assessed and limited the probability of accidental explosions during and after completion of mission operations; (iii) limited the probability of the space station becoming a source of debris by collisions with large debris or other operational space stations; and (iv) detailed the post-mission disposal plans for the space station at end of life, including an assessment of the probability of human casualty as a result. Thus, this application conforms to the requirements of Section 5.64(b) of the Commission's rules, 47 C.F.R. § 5.64(b).

B. Veery-FS1 Satellite Launch and Operations

Veery is flying in the FOSSA Systems PocketPod dispenser, which is flying on a Momentus Vigoride transfer vehicle released from a SpaceX Falcon 9 launch vehicle. This launch will take place in the United States. The mission authorization and operation timeframes are included in the Table 1 below.

Table 1. Mission Authorization and Operation Timeframe

[4] *See* Attachment 1 - Veery-FS1 Orbital Debris Assessment Report (ODAR).

Authorization grant-by date (integration):	March 21, 2022
Launch date:	June 1, 2022
Date for initiation of on-orbit operations:	0-3 days after launch
Expected mission duration:	6 months

Upon release, Veery-FS1's power system will be reconnected to its batteries by its separation switches. This will power the microcontroller system, which will initiate timers that ensure deployables are released and radio transmissions begin at a safe separation distance from the transfer vehicle. When the deployment timer is completed, the microcontroller will deploy solar panels. When the radio timer is completed, the radios will begin communications with the Iridium satellite network and with Care Weather's mobile ground station operated in Utah.

C. VHF Communications

The Veery-FS1 satellite will utilize a VHF radio to communicate with Care Weather's Nest-1 mobile ground station operated in Utah. This system employs the 137-138 MHz band for space-to-earth links and the 148-149.9 MHz band for earth-to-space links, consistent with the US and International Table of Frequency Allocations. For the Veery-FS1 mission, Care Weather proposes to operate on the 137.935-137.965 MHz band in the space-to-Earth direction and on the 149.1-149.15 MHz band in the Earth-to-space direction. This accommodates one channel in each of the uplink and downlink directions. The Veery-FS1 satellite for which an authorization is sought will transmit only when within line of sight of Care Weather's Nest-1 mobile U.S. Earth station in Utah, and only when commanded by the Earth station. No other Earth stations will transmit to the satellite.

The satellite and the land station will be in communication at most 2% of the time or a maximum of 28 minutes of contact per day. Typical communications are expected to be initiated by the ground station after the satellite crosses an elevation of 10 degrees, continuing until the satellite again crosses below an elevation of 10 degrees.

The satellite VHF communications system includes a Care Weather Trill radio and deployed, tape-spring dipole antenna, both manufactured by Care Weather. The radio operates with a bandwidth of 60 kHz (the 137.935 – 137.995 MHz band). The dipole antenna has a peak gain of 2.15 dBi.

The mobile Nest-1 ground station is manufactured by Care Weather and is collapsible, enabling it to be moved to a variety of locations. This supports experimentation of ground station site compatibility with the VHF radio. Nest-1 uses a Y1363 Yagi antenna with a peak gain of 7.1 dBi.

D. Iridium Satellite Relay

The Veery-FS1 satellite will utilize an Iridium satellite relay to communicate with Care Weather mission control. The Iridium satellite relay system uses an Iridium 9603 satellite modem, which has been routinely granted in other circumstances,[5] and body-mounted 25mm Iridium single-feed, non-deployable ceramic patch antenna manufactured by Taoglas, Model

[5] *See, e.g.*, Care Weather Technologies, Inc., ELS File No. 1840-EX-ST-2020 (authorizing communication with the Iridium 9603 modem); *see also* Capitol Technology University, ELS File No. 0033-EX-CN-2017 (authorizing communication with the Iridium 9603 modem); *see also* Thomas Jefferson High School Partnership Fund Inc., ELS File No. 0950-EX-CN-2018) (authorizing communication with the Iridium 9602 modem).

CGIP.25.4.A.02.[6] The antenna has a peak gain of 5 dBi and operates with a bandwidth of 7.275 MHz (the 1618.725 – 1626.5 MHz band). A companion application for experimental authority will be filed by Iridium authorizing the communications from the Iridium satellite system to the Veery-FS1 satellite.

E. Experimental Subsystem Descriptions

Since it's last mission, Care Weather has developed additional custom satellite bus subsystems that require in-flight testing to advance their readiness for integration with a future satellite scatterometer. These systems include:

- *Care Weather Trill VHF radio, Care Weather dipole antenna, and Nest-1 ground station:* measurements of space-to-ground and ground-to-space signal strength will validate radio and ground station link budgets. Measurements of attitude will validate the gain pattern. Data rate and error counts of bent-pipe calibration packets will validate link budget predictions system downlink and uplink performance. Synchronous operations will validate and inform Care Weather's tasking, telemetry, command, and downlink operations procedures.
- *Care Weather high-accuracy, integrated attitude determination system:* attitude determination software will integrate the star tracker, fine sun sensor, and inertial measurement unit ("IMU") measurements to estimate the spacecraft attitude. Raw measurements from these systems will be downlinked to ground for evaluation of attitude determination performance. In addition, solar charge currents, system

[6] See Attachment 2 - Antenna Beam Patterns. Note that the Taoglas antenna beam pattern information includes antenna performance at 1575.42 MHz for GPS/Galileo reception. However, only the radiation pattern at 1621 MHz for communication with the Iridium system is relevant to this application.

temperatures, and space-to-ground signal strength will be used to verify the performance over various combinations of solar illumination, rotation rates, and thermal cycling.

- *Care Weather high-precision, integrated attitude control system:* estimations of attitude generated by the attitude determination system will be used to measure the accuracy and settling time of the magnetorquer attitude control system and control software.
- *Next-generation Care Weather computing, power, instrumentation, and software systems:* Informed by the Veery-RL1 missions, the computing, power, instrumentation, and software systems of Veery-FS1 contain many refinements over past iterations. The computing system incorporates a higher-speed processor with more flexible computing capabilities, the power system has improved efficiency, the instrumentation system is more extensive providing more thermal and power measurements of the satellite with greater detail, and the software is more capable of managing the many added systems of Veery-FS1.

These systems continue to be extensively tested on the ground and require spaceflight testing to further evaluate performance and achieve final design parameters.

F. Points of Contact

Primary contact who can terminate ALL satellite transmissions.

Point of Contact Name: Patrick Walton
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Secondary contact who can terminate ALL satellite transmissions.

Point of Contact Name: Alex Laraway
Organization Name: Care Weather Technologies
Role: CTO, System Engineer
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G. International Telecommunications Union ("ITU") Compliance

It is understood that the commission will submit filings to the ITU on behalf of the applicant pursuant to international obligations for the coordination and registration of space network systems. Care Weather is aware that processing fees will now be charged by the ITU for satellite network filings and has attached a letter accepting responsibility to pay any cost recovery fees associated with this application.[7] Care Weather has also prepared the ITU Advance Publication Information ("API") submission along with the applicable Space Capture V.9 information for the Veery-FS1 satellite.[8]

H. NOAA Commercial Remote Sensing Regulatory Compliance

NOAA has determined that no Earth remote sensing license is required for the Hatchling Veery system.[9] Veery-FS1 is a Hatchling Veery system and the factual circumstances of Veery-FS1 match those provided to NOAA.

I. Electromagnetic Compatibility

Care Weather recognizes its limited experimental operations cannot create interference into, and must accept interference from, authorized systems (including satellite systems) in the

[7] *See* Attachment 3 - ITU Cost Recovery Letter.
[8] See Attachment 4 - API Cover Letter; see also Attachment 5 - Veery-FS1 ITU SpaceCap; see also Attachment 6 - Veery-FS1 ITU SpaceVal Report (note that Attachment 9 demonstrates that the coordination warning is unwarranted due to a lack of local ground stations in the band); see also Attachment 7 - Veery-FS1 ITU SpacePub Report.
[9] *See* Attachment 8 - Hatchling Veery NOAA Determination Letter

band. Care Weather will seek to coordinate its proposed operations with co-frequency operators to the extent required. Pursuant to footnote US323, Care Weather has attached an electromagnetic compatibility study demonstrating that there are no nearby land stations with which the Nest-1 land station needs to be coordinated.[10]

J. Public Interest Considerations

The Veery-FS1 mission is an integral part of Care Weather's technology development plan and ultimate goal of developing and operating low-cost, miniaturized, satellite-based scatterometers that increase ocean surface vector wind measurements exponentially to enhance weather forecasting for the protection of lives and livelihoods. Care Weather is partnering with and has received support from a range of U.S. government agencies and affiliated academic institutions, including NASA, the Air Force, the U.S. Forest Service and the University of Utah, as well as U.S. international partners, including the U.K. Meteorological Office.[11] Thus, there is a strong government interest in conducting the Veery-FS1 mission.

III. Conclusion

In view of the foregoing, Care Weather respectfully requests a six-month experimental STA to operate the Veery-FS1 satellite in accordance with the specifications, launch, and integration schedule described herein.

[10] *See* Attachment 9 - Veery-FS1 EMC Study
[11] *See* Attachment 10 - Letters of Interest.